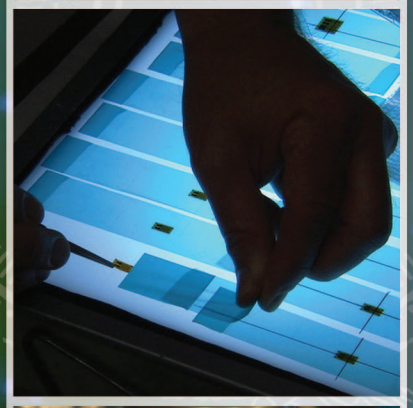
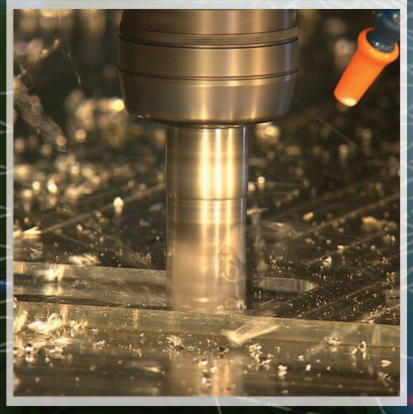
National Aeronautics and Space Administration





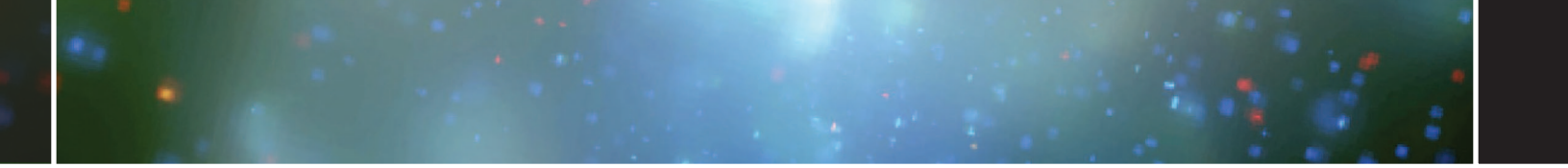
Marshall Space Flight Center

Technology Transfer Office

Saluting our most significant technology successes

accomplishments

www.nasa.gov



Since it was established in 1960, Marshall Space Flight Center has built launch vehicles, spacecraft, and scientific instruments that have played a critical role in moving the nation forward with its focus on space exploration and scientific discovery.

Learn how Marshall's strengths and proven capabilities support NASA's goal of integrating science and exploration in innovative ways for maximum return on the nation's investment.

Table of contents

Who We Are and How We Work

The mission of the Technology Transfer Office at NASA's Marshall Space Flight Center is to provide technology solutions for mission directorates, programs, and projects through joint partnerships with industry, academia, government agencies, and national laboratories.

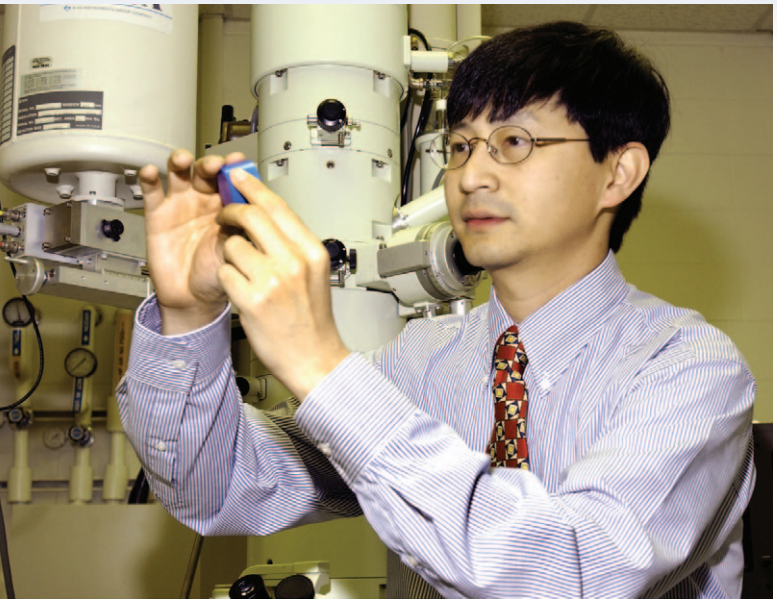
To achieve this mission, the office assists innovators at the Center by evaluating new technologies for possible commercial licensing, actively marketing technologies that show a high degree of potential, seeking out prospective licensees, and negotiating win-win deals. The office also develops partnerships with external organizations—companies, universities, other federal agencies, and national laboratories—to leverage the partner's expertise and infuse new technology into NASA programs.

The technology transfer team also manages the Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programs, which help stimulate technological innovation in the private sector for the benefit of NASA and increase the commercial application of promising technologies.

Marshall Space Flight Center's Propulsion Research Laboratory

Meet Our Innovators

Innovation from within...



Jonathan Lee

As a materials engineer at Marshall Space Flight Center, Jonathan Lee is responsible for developing advanced materials for space programs and solving material issues for NASA applications. He is living proof that technology transfer can take many different forms and benefit taxpayers in different and exciting ways.

Lee is the co-inventor of a high-strength, heat-tolerant aluminum alloy that is a commercial success and was recognized by the Center as Invention of the Year in 2003. Originally developed through a partnership with NASA and a major automobile manufacturer for use in automotive pistons, the alloy has been licensed to Bombardier Recreational Products, Inc. (BRP) for marine applications, and is helping BRP revive the two-stroke outboard engine it inherited from Outboard Motor Corporation in 2001. *(See related story on page 5.)* NASA is also pursuing other marine and non-marine applications for the technology.

> "NASA's existence depends on tax dollars, and we need to use these funds very carefully. If our ideas and inventions can be used to benefit both NASA and the public, we are making the best use of our resources."

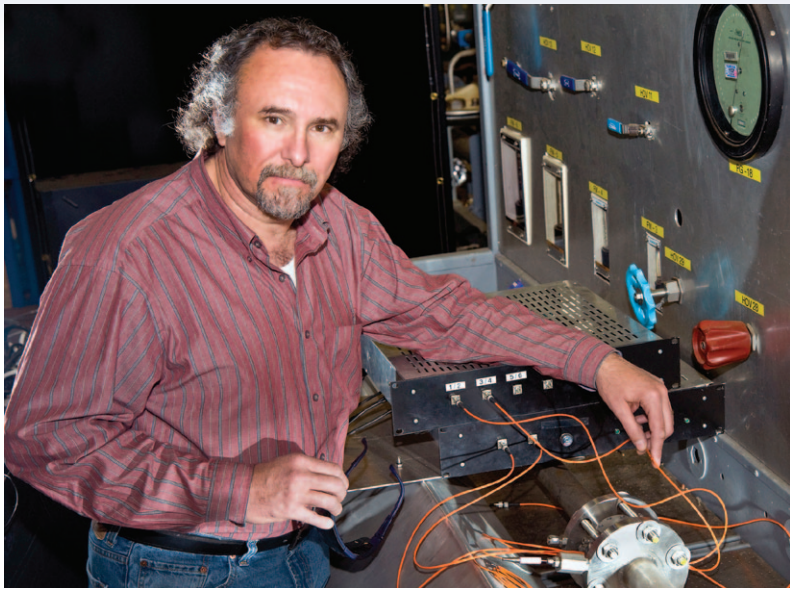
For the past four years, Lee has been working on the next-generation crew launch vehicle. His responsibilities have included developing material properties for the aluminum-lithium 2195 alloy by collecting data on welding, mechanical strength, and fracture mechanics, and identifying how this relatively new and high-strength aerospace alloy can be used on the launch vehicle rocket. He has also been testing and collecting data on the hydrogen effects of a titanium alloy that will be used in manufacturing the high-pressure vessels mounted inside the upper-stage liquid hydrogen tank.

Lee's work on advanced materials has expanded NASA's understanding about how hydrogen reacts with different metals. Hydrogen that is used by NASA in rocket fuel can cause hydrogen environment embrittlement, a condition that leads to cracking in metals exposed to gaseous hydrogen and poses a threat to launch vehicles. Lee has developed a simple analytical theory that can be used to predict the embrittlement behavior of metals when exposed to hydrogen. He has also co-invented a new nickel-based superalloy that resists the damaging effects of hydrogen better than the conventional superalloy Inconel 718, potentially contributing to the commercial viability of hydrogen as a clean-burning fuel in future power generation plants.

In addition to benefitting the crew launch vehicle project, Lee's expertise regarding hydrogen embrittlement has made him a valuable resource for other projects outside of NASA. The U.S. Department of Energy (DOE) has consulted with Lee on several projects it is conducting related to the use of hydrogen gas as an alternative clean energy source. Lee's research is being used by the DOE to develop hydrogen testing standards and codes as well as hydrogen-resistant materials for deployment in reactors, pipelines, and other infrastructure that will be needed to generate and transport hydrogen gas on a large scale. He has also participated with other national laboratories on an initiative to build a hydrogen-powered automobile and test a hydrogen fueling station for the vehicle.

Lee minored in art at the University of Alabama in Huntsville, Alabama and credits his training as an artist for nurturing the creativity he uses as an inventor.

John Wiley



John Wiley, lead test engineer at the Component Development Facility at Marshall Space Flight Center, has a passion for taking measurements and analyzing data. This passion has inspired him to develop innovative technology that he can use to do his job more effectively and help improve the engineering of NASA flight components and systems.

"I strongly believe that we can build better rocket engines through better measurements," Wiley says. He feels that, in many cases, the foundations of sensing technology is more than 100 years old, relies on indirect measurements, and that improvements in measurement technology will provide data that more closely reflects the actual physical phenomena needed to anchor design models. Wiley explains, "Models anchored with valid data will guide us down the right path for improved hardware design. There are clearly obstacles to overcome in the development of efficient launch and in-space propulsion systems. I believe the foundation on which we will overcome these obstacles includes better measurements and utilizing available computing power in order to collect data on highly dynamic systems."

For NASA, more accurate readings of fuel flow can reduce the amount of fuel that is carried on a space mission, creating more room for other payload. That is the purpose of the Fiber Optic Liquid Mass Flow Sensor that Wiley helped develop for use on NASA propulsion systems. The device relies on an optical beam that directly measures the dispersion in a cryogenic liquid flow. From this data, the value of the density within the flow and fluid velocity can be identified, resulting in a measurement of the mass flow. Prototypes of the mass flow sensor are currently being tested, and the technology has been licensed commercially. In addition to aerospace applications, the technology can be used on almost any fluid flow system, particularly in environments in which direct measurements are difficult to obtain—such as in hazardous chemical and industrial environments.

Wiley also has been a co-inventor on two other sensor devices—Cryogenic and Non-Cryogenic Optical Liquid Level Instrument for Stratified Conditions and Dual-Parameter High-Temperature/High-Pressure Optical Combustion Chamber Sensor—that have been designed to improve measurements in NASA fuel tanks and rocket engines. Wiley credits the Technology Transfer Office at NASA's Marshall Space Flight Center for playing a key role in the development of these new technologies.

"The assistance of the Technology Transfer Office, through funding and other support, has helped to make these innovations possible," Wiley states. "When I needed funding for testing, they stepped to the plate. It wasn't a lot of money, but it was very important. Without them, I would have lost a lot of my enthusiasm."

> "The assistance of the Technology Transfer Office, through funding and other support, has helped to make these innovations possible."

Our Featured Achievements

Licensing successes

NASA actively pursues potential licensees and negotiates licensing agreements that allow the private sector to use NASA technology to create innovative new products. These commercial products contribute to global competition and the economy, and they benefit the public by providing resources that improve health and safety, transportation, computer technology, and other aspects of everyday life.

Using Optics Technology to Improve Vision Screening for Children

Incorporating a process called photorefraction, scientists at NASA's Marshall Space Flight Center collaborated with research ophthalmologists and optometrists to adapt optics technology used in space telescopes for use in eye screening. NASA transferred the exclusive license for its camera-based system to Vision Research Corporation in 1991. The company's VisiScreen™ Ocular Screening System-Clinical provides fast, simple, and non-invasive early screening for conditions such as nearsightedness, farsightedness, astigmatism, cataracts, and amblyopia (or "lazy eye"), the leading cause of preventable blindness in children. The technology has won several awards, including an R&D 100 Award and the Space Foundation's Space Technology Hall of Fame award, and has been used to identify possible vision problems in more than four million children since its commercialization.

VisiScreen is a trademark of Vision Research Corporation.

Creating a Handheld Scanner to Detect and Analyze Light Elements

With assistance from a Space Act Agreement, innovators at Marshall Space Flight Center and KeyMaster Technologies, Inc., developed a vacuum attachment for a handheld X-ray fluorescence (XRF) analyzer that provides expanded capacity for detecting light-element alloys that are present in materials. The award-winning technology was patented and licensed to KeyMaster, which has since been acquired by Bruker Corporation. The resulting Tracer III-SD and Tracer III-V XRF analyzers have been used commercially throughout the world for conservation and authentication of artwork and other valuable objects, as well as for archeology, research, and in a variety of other applications. NASA's Space Shuttle Propulsion Office has purchased the devices to evaluate light-element alloys, particularly aluminum, that are prevalent in flight hardware, and it has used them to conduct failure analysis, analyze welding rods, and evaluate hardware for contamination, corrosion, and material deviations.

Enhancing Friction Stir Welding with NASA Technology

The auto-adjustable pin tool designed at Marshall Space Flight Center is an improvement to the friction stir welding (FSW) process already widely recognized for providing greatly improved weld properties over conventional fusion welds. The NASA technology eliminates the "keyhole," a pinhole left at the end of a weld, which had been one of the few drawbacks to FSW, and it also enables the welding of material that tapers from one thickness to another, as found in the space shuttle external tank. The innovation has contributed to customized FSW that has been proven to provide routinely reliable welds. The technology, which has been licensed by MTS Systems Corporation and MCE Technologies, Inc., is enabling cost-competitive, efficient, and versatile FSW applications for automotive, shipbuilding, and other industries.

Using High-Strength Alloy to Revive BRP's Two-Stroke Engine

In need of an inexpensive, heat-resistant piston for a two-stroke engine that could meet strict environmental standards, Bombardier Recreational Products, Inc., (BRP) turned to an alloy originally developed in the 1990s by scientists at NASA's Marshall Space Flight Center to produce cleaner burning automotive pistons. NASA licensed the high-strength, heat-tolerant MSFC 398 aluminum alloy to BRP in 2003, and the company has used the alloy to produce more than 500,000 pistons for its Evinrude™ E-TEC™ outboard engine. The technology has won several awards, including the Society of Automotive Engineers award for Environmental Excellence in Transportation. NASA's investment in the alloy's development is benefitting U.S. taxpayers and has paid off many times over in royalty earnings. NASA also recently licensed the alloy to a company that develops large-scale fans for tunnels and other commercial applications and is investigating other uses for the technology, including its use in net-shape casting of propulsion systems in rocket-powered engines and in other two-stroke and air-cooled four-stroke engines.

Evinrude and E-TEC are trademarks of Bombardier Recreational Products, Inc.

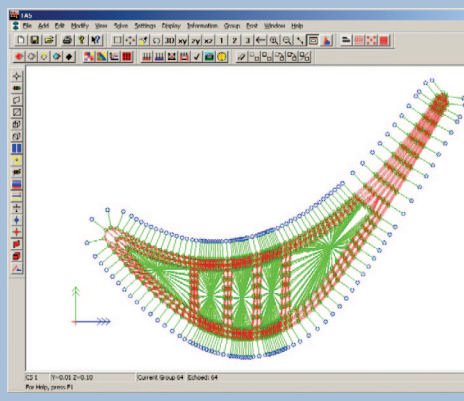
Measuring Fluid Flow with Greater Accuracy and Reliability

Founders of A+ FlowTek collaborated with Marshall Space Flight Center to develop an advanced flow measurement device through a Space Act Agreement. The patented technology is simple and outperforms previous methods of metering high-velocity fluid flows in diverse aerospace applications and in chemical processing facilities, and it can be modified to perform additional functions such as fluid mixing and conditioning. This technology was licensed to A+ FlowTek in 2003, and the resulting Balanced Flow Meter became the company's flagship product. Commercial activities have been highly successful, with more than 4,000 units sold and distributor agreements signed or pending for regions in the U.S., South America, Europe, and Asia. Several Fortune 500 chemical and petroleum companies have made the Balanced Flow Meter standard in all of their facilities.

Improving Flow Network Analysis with User-Friendly Software

Researchers at Marshall Space Flight Center have patented software for analyzing steady state and transient flow in complex fluid networks. Originally developed to analyze propulsion systems, the Generalized Fluid System Simulation Program (GFSSP) version 5.0 has been modified to work as a general-purpose, versatile flow modeling solution. With its flexibility and user-friendly graphical interface, this winner of NASA's Software of the Year Award has enabled engineers to develop models for complex flow circuits and save time and avoid costs associated with writing code from scratch. In 2001, Concepts NREC licensed GFSSP, making it an integral technology in the company's Cooled Turbine Airfoil Agile Design System (CTAADS™), an advanced tool for designing and analyzing actively cooled turbine blades. With sales to major aerospace organizations, the CTAADS tool has become a successful product for the company.

CTAADS is a trademark of Concepts NREC.



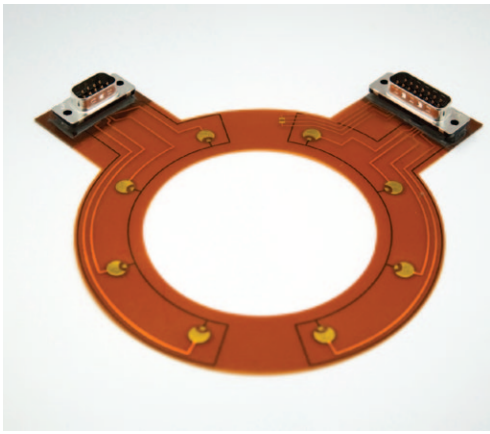
Our Featured Achievements

SBIR/STTR successes

NASA's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs use a three-phased contract approach to enable small businesses to develop technologies in response to a specific set of NASA mission-driven needs. These partnerships have produced excellent results for NASA and continue to help NASA meet its goals while helping small businesses grow.

Acellent Works With NASA to Develop Innovative Structural Health Management Solutions

In 2001, Acellent Technologies, Inc. began working with Marshall Space Flight Center under an SBIR contract to adapt its SMART Layer® (Stanford Multi-Actuator Receiver Transduction Layer) sensor technology to perform nondestructive structural health monitoring (SHM) of NASA equipment. As a result of this and subsequent SBIR contracts, NASA has received a reliable new mechanism to inspect aerospace vehicles and other structures for structural damage, and Acellent has developed a robust SHM system with excellent commercial potential.



Acellent's SMART Layer sensor technology includes a network of distributed piezoelectric sensors and actuators embedded on a thin dielectric carrier film that can be mounted on metal structures or embedded in composite structures to detect damage and provide early warning before failure takes place. While competing SHM systems typically use sensors and actuators arrayed at various locations on a structure, the Acellent technology contains an entire sensor and actuator array, making it unnecessary to install each sensor and actuator individually. Because the SMART Layer sensor technology is pre-networked and pre-positioned, installation is simple.

In 2009 and 2010, Marshall supported the implementation and testing of the Acellent pitch-catch piezoelectric sensor on the Composite Crew Module (CCM) for the Ares Program. The CCM is a full-scale version of the Orion spacecraft.

The original SBIR contract with Acellent led to the development of a hybrid network of sensors—including piezoelectric actuators embedded along with fiber optic detection sensors—that can be embedded in the SMART Layer sheet. The new hybrid SMART Layer sensor technology offers expanded capability to monitor strain and moisture in aerospace applications. In addition to providing NASA with quick, nondestructive evaluation and longer term health monitoring, the SBIR technology has the potential to monitor material processing, detect structural defects, detect corrosion, characterize load environments, and predict material life.

Additional SBIR contracts with NASA helped Acellent to improve and optimize its technology, leading to sales contracts with many major aerospace companies.

SMART Layer is a registered trademark of Acellent Technologies, Inc.

ASRI Creates Award-Winning Software to Simplify Vibration Analysis

Much like a doctor uses a patient's heartbeat or blood pressure to inform a medical diagnosis, NASA engineers use vibration signal analysis to assess engine ground test and flight performance and diagnose mechanical issues. Working with Marshall Space Flight Center under SBIR contracts, AI Signal Research, Inc. (ASRI) has developed an innovative software package that allows engineers to simply point and click to quickly analyze complex vibration and oscillation data using a personal computer.

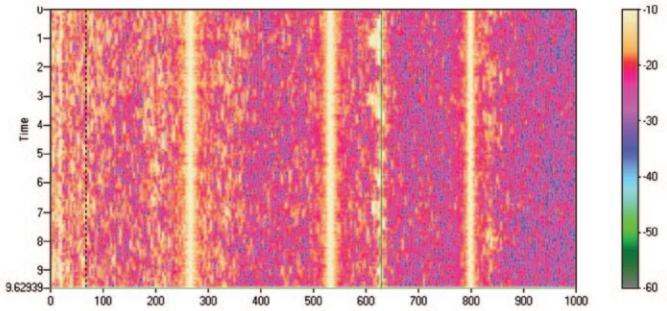
In the early years of development of the space shuttle main engine, NASA engineers used vibration analysis to assess problems, but the task was costly, tedious, and time consuming. By the 1990s, the power of personal computers advanced significantly and NASA awarded ASRI an SBIR contract to enhance the method of vibration signal analysis. Through follow-on SBIR contracts, ASRI developed the PC-SIGNAL® software package, which allowed for quick and easy identification of potential design issues related not only to vibration but also other signals resulting from sound, strain, and fluid flow.

Today, NASA employs the PC-SIGNAL software on a daily basis when developing and testing propulsion systems. It is used for processing dynamic data and other diagnostic analysis, such as analyzing engine health data from space shuttle missions, flow testing to identify and resolve fluctuations in pressure in turbopumps, and in designing new rockets.

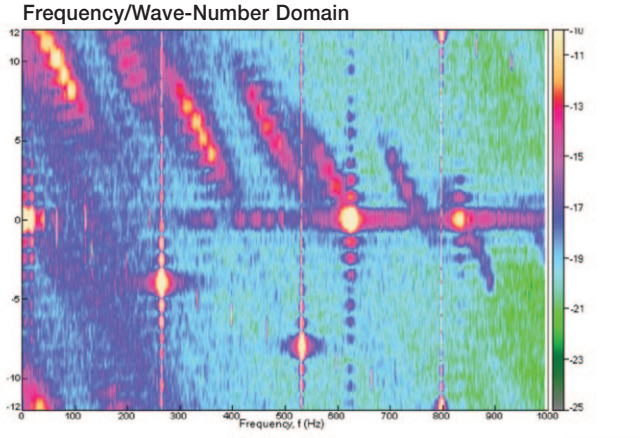
With its roots in software development for NASA, ASRI has grown during the last 20 years and now provides technical services to the U.S. Department of Defense and commercial customers, in addition to NASA. The PC-SIGNAL software is used widely by rocket engine manufacturers, as well as in the aircraft/helicopter and transportation industries and in the nuclear power industry to conduct dynamic signal analysis, system health monitoring, flight data analysis, flow data analysis, and fatigue analysis and monitoring.

PC-SIGNAL is a registered trademark of AI Signal Research, Inc.

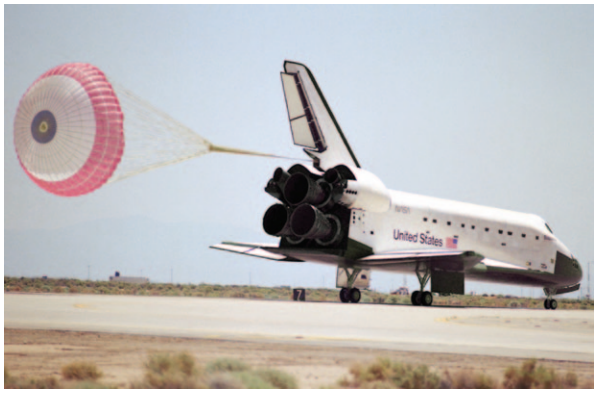
PSD Spectrogram in Frequency/Time Domain



Frequency/Wave-Number Spectrum in Frequency/Wave-Number Domain



Multiple-Domains Analysis by PC-SIGNAL of Space Shuttle Main Engine Fuel Pump Inducer Water Flow Test



Our Featured Achievements

Seed Fund successes

Furthering technologies and maximizing return on investment

From 2006-2010, NASA's Seed Fund initiative enhanced the agency's ability to meet mission directorate technology goals by providing funding to address barriers and initiate cost-shared, joint-development partnerships. These one-year projects involved collaboration among three principal partners: a NASA partnership manager at a field center, a co-principal investigator within a NASA program or project office, and an external co-principal investigator from the private sector, academia, or other government laboratory.

NASA Teams with Orion Propulsion to Develop Composite Tanks for Cryogenic Fluids

NASA and the U.S. Air Force have funded a variety of cryogenic composite tank development programs in the past. Their success was limited, in part, because of a lack of a methodical building-block approach to the development of the technology. Such programs also focused on very large-scale vessels produced by off-the-shelf materials and used at rather low pressures. Additional work was needed to determine the technology limitations and to develop and test new technologies in relevant environments.

In partnership with Orion Propulsion—which has since been purchased by Dynetics, a Huntsville, Alabama technology company—Marshall Space Flight Center used the Seed Fund to create a thorough building-block approach to the development and understanding of cryogenic composite over wrapped pressure vessels (COPVs) and to apply this approach to all-composite vessels that could be tested in a propulsion system. Testing helped reduce the weight and development time of COPVs, increased their reliability, and in turn led to the development of several new designs and fabrication methods that have helped to make them ideal containers for such cryogenic fluids as liquid methane and liquid hydrogen. NASA's innovations offer improvements in structural integrity, enhancing protection against impact, harsh environments, and fire. Improvements are applicable to important aerospace needs, such as propulsion systems, and are being marketed for use in new and growing fields including natural gas transportation.

NASA and Honeywell Explore a Regenerable System of Air Quality Management

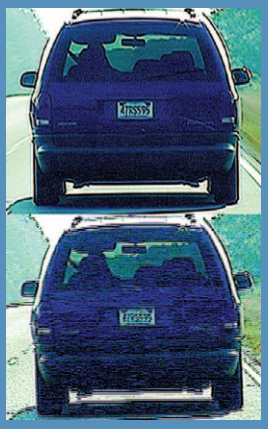
Trace contaminant control is a difficult task for equipment in a closed-cabin environment such as the International Space Station. Ammonia compounds and light alcohols are particularly difficult to remove from a closed cabin, and large quantities of adsorbents are required to effectively remove them.

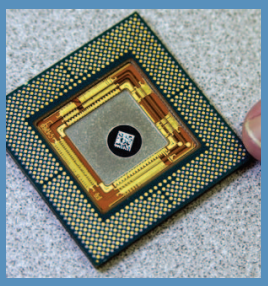
Marshall Space Flight Center and Honeywell International Inc. used the Seed Fund to explore the development of a regenerable system of contaminant control that would reduce the quantity of adsorbents using photocatalytic oxidation (PCO). Specifically, a subscale PCO module was fabricated to test the effectiveness of a trace contaminant removal system for reducing the concentration of primary organic and inorganic contaminants, while ensuring negligible production of undesirable secondary reaction products. Additional modeling will address process scale-up issues required to provide optimum trace contaminant removal. This Seed Fund effort resulted in the PCO module advancing from a technology readiness level of 3 to 5. The PCO technology is applicable to space and aerospace applications and commercial aircraft cabins.

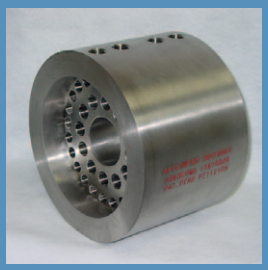
Awards and Recognition

Recognizing innovators and technologies for their successes and their potential

Making our innovations available for use by academia, industry, and other government agencies is paramount to our mission. The Technology Transfer Office actively seeks patents and recognition for our most promising technologies to further that mission.







Awards and Recognition

Space Technology Hall of Fame

2003: VisiScreen Ocular Screening
2001: Data Matrix
2001: Video Image Stabilization and Registration (VISAR)
2000: Light-Emitting Diodes (LEDs) for Medical Applications

Federal Laboratory Consortium Excellence in Technology Transfer Award

National winners:
2010: Balanced Flow Meter
2009: Friction Stir Welding (FSW) Auto-Adjustable Pin Tool
2008: TRACeR X-Ray Fluorescence (XRF) Scanner
2006: High-Strength, Wear-Resistant Aluminum Alloy
2003: Data Matrix
2002: VISAR

Regional winners:
2010: Balanced Flow Meter
2007: TRACeR XRF Scanner
2005: High-Strength, Wear-Resistant Aluminum Alloy
1997: Data Matrix

MSFC Invention of the Year Award

2006: Balanced Flow Meter
2005: Data Matrix
2004: Composite Tanks
2003: High-Strength, Wear-Resistant Aluminum Alloy
2002: VISAR
2000: FSW Auto-Adjustable Pin Tool

NASA Commercial Invention of the Year Award

2002: VISAR

NASA Software of the Year Award

2001: GFSSP

Institute of Industrial Engineers Award for Technical Innovation in Industrial Engineering

2007: Data Matrix

Society of Automotive Engineers Environmental Excellence in Transportation Award

2004: High-Strength, Wear-Resistant Aluminum Alloy

Tibbets Award

2006: Light-Emitting Diodes for Medical Applications

Contact Us

Want to work with us? Find out how to partner with us for joint research and development as well as how to license our technologies at:

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